4.5 Fish and Wildlife Surveillance

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Contaminants in fish and wildlife species that inhabit the Columbia River and Hanford Site are monitored for several reasons. Wildlife have access to areas of the Site containing radioactive contamination, and fish can be exposed to contamination entering the river along the shoreline. Fish and some wildlife species exposed to Hanford effluents might be harvested and may potentially contribute to the dose to the offsite public. In addition, detection of radionuclides in wildlife may indicate that wildlife are entering contaminated areas (for example, burrowing in waste burial grounds) or that radioactive material is moving out of these restricted areas (for example, through blowing dust). Consequently, samples are collected at various locations annually, generally during the hunting or fishing season (Figure 4.5.1). More detailed rationale for selection of specific species sampled in 1995 can be found in DOE (1994).

Samples of fish and wildlife collected from distant locations unaffected by Hanford effluents (background locations) are analyzed, and results are compared to results from Hanford samples to identify differences. Routine background sampling is conducted roughly every 5 years at locations believed to be unaffected by Hanford releases. Background data also may be collected during special studies or sampling efforts. In 1995, background contaminant concentrations were measured in whitefish from the Wenatchee River, goose eggshells from the Priest Rapids Dam area, and pigeons from Walla Walla and Seattle.

As a result of changing Site operations, fish and wildlife sampling frequencies were modified significantly in 1995. Species that have been collected annually were placed on a rotating schedule so that surveillance of all key species will be accomplished over a three-year period. Contributing factors supporting these changes included the elimination of many radiological source terms onsite and a decrease in environmental concentrations of radionuclides of interest. Several radionuclides that were monitored in the past have not been detected in recent wildlife samples because either they are no longer present in the environment in sufficient amounts to accumulate in wildlife, or surveillance has demonstrated that they do not accumulate in fish or wildlife tissues of interest. Air and water sampling provides additional information on the potential exposure of fish and wildlife. Consequently, the needs of the sitewide fish and wildlife surveillance program can be satisfied by less frequent sampling.

For each species of fish or wildlife, radionuclides are selected for analysis based on the potential for the contaminant to be found at the sampling site and the potential to accumulate in the organism (Table 4.5.1). At Hanford, cesium-137 and strontium-90 historically have been the most frequently measured radionuclides in fish and wildlife.

Strontium-90 is chemically similar to calcium; consequently, it accumulates in hard tissues high in calcium such as bone, antlers, and eggshells. It has a long biological half-life in hard tissue and may profile the lifetime exposure of an organism to strontium-90. However, strontium-90 generally does not contribute much to human dose because it does not accumulate in edible portions of fish and wildlife. Spring water in the 100-N Area is the primary source of strontium-90 from Hanford to the Columbia River; however, the current contribution, relative to historical fallout from atmospheric weapons testing, is small (Jaquish 1993).

Cesium-137 is particularly important because it is chemically similar to potassium and is found in the muscle tissue of fish and wildlife. Cesium-137 has a relatively short biological half-life and is an indicator of more recent exposure to radioactive materials. It is also a major constituent of historical fallout.

Fish and wildlife samples were analyzed by gamma scan to detect a number of gamma emitters (see Appendix E). However, gamma scan results for most radionuclides are not discussed below because concentrations were too low to measure or because measured concentrations were

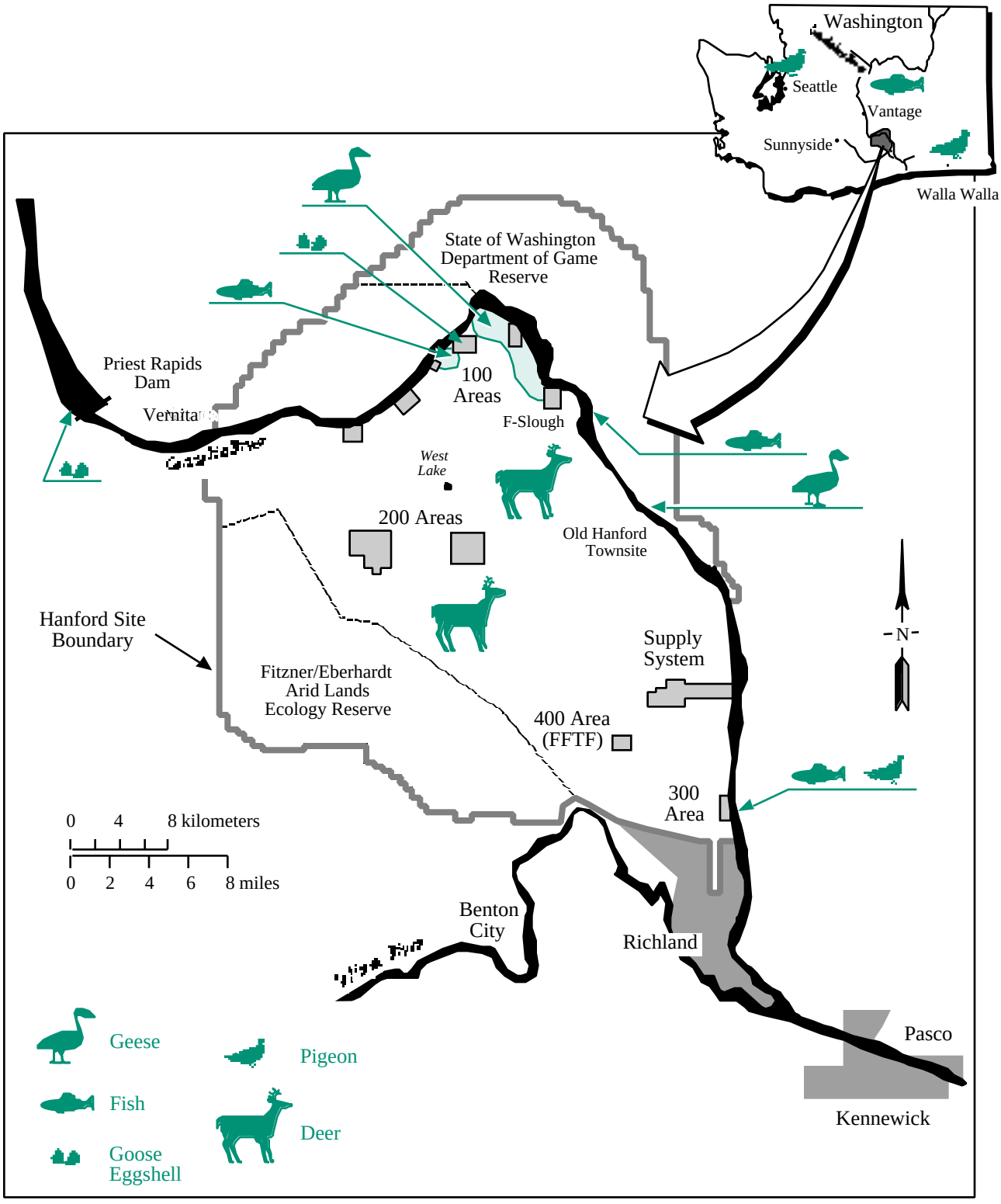

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Figure 4.5.1. Fish and Wildlife Sampling Locations, 1995

Table 4.5.1. Locations, Species, and Contaminants Sampled for Fish and Wildlife, 1995

Media	Number of Species	Offsite Locations	Onsite Locations	Contaminants Sampled/Number of Locations				
				Gamma	^{90}Sr[a]	^{99}Tc	U	Metals
Fish (Sucker, Whitefish)	2	1[b]	2	3	3	1	1	0
Geese	1	0	2	2	2	0	0	0
Pigeons	1	2[c]	1	0	0	0	0	3
Mule deer	1	0	2	5	2	0	0	0

(a) Analyzed in bone and some muscle samples.
(b) Background samples collected from the Wenatchee River.
(c) Background samples collected from Seattle and Walla Walla.

considered artifacts of low background counts. Low background counts occur at random intervals during sample counting and can produce occasional spurious results.

For many radionuclides, concentrations are below levels that can be detected by the analytical laboratory. When this occurs for an entire group of samples, two times the total propagated analytical error is used as an estimate of the nominal detection level for that analyte and particular media. Propagated errors for all results may be found in Bisping (1996).

Specific radiochemical analyses were performed on fish and wildlife samples to measure plutonium-238, plutonium-239,240; technetium-99; uranium-234; uranium-235; and uranium-238. These radionuclides provide an indication of contaminant levels in edible portions of fish and wildlife and are useful when estimating doses to consumers. These radionuclides are of interest because:

- Technetium-99 is known to enter the Columbia River in shoreline seeps and springs and has a long half-life. Its potential to accumulate in fish is not well-known; however, concentrations of technetium-99 in fish tissues have not been found above the detection limit of 1.0 pCi/g in the past 5 years. In January 1995, three whitefish were sampled for technetium-99 analysis.

- Isotopes of uranium enter the Columbia River in springs near the 300 Area and have been reported at slightly elevated concentrations in soil and vegetation in and near the 300 Area. Prior sampling indicated that uranium is not found in fish muscle; therefore, analysis was shifted to offal samples (identified as carcass samples before 1994) because uranium accumulates in fish bones.

- Isotopes of plutonium accumulate in liver and may also be deposited in bone. In 1995, liver tissue from selected wildlife was analyzed to monitor potential exposure to terrestrial contamination.

In addition to performing routine fish and wildlife surveillance activities, metal concentrations were monitored in muscle, liver, and kidney tissues of pigeons collected from the 300 Area and from two control locations, Seattle and Walla Walla as part of a graduate student study. Metal concentrations were determined by inductively coupled plasma emission-mass spectrometry. This method provides measurements of several trace metals simultaneously: silver (Ag), arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), antimony (Sb), thallium (Tl), and zinc (Zn). Pigeons normally are not consumed by hunters; however, elevated metal concentrations in pigeon muscle may indicate the potential for metals to accumulate in other species of gamebirds. Kidney and liver tissues were analyzed because these organs are involved with the metabolism and excretion of trace metals and may provide evidence of environmental exposure to these metals.

Fish Sampling

Whitefish and suckers were the only fish species collected from the Hanford Reach in the summer and winter of 1995. Whitefish were collected because historically they have been the Columbia River sport fish that accumulated the highest radionuclide concentrations. Whitefish routinely are collected from the Columbia River along the shoreline between the 100-N and 100-D Areas and along the 300 Area shoreline. Suckers were collected from the 300 Area in 1995 as a replacement for whitefish because river conditions in the winter were not conducive for the collection of whitefish. However, three whitefish were collected in January 1995. Whitefish and suckers consume the same foods, and prior studies have indicated that suckers generally accumulate similar or slightly higher levels of contaminants than whitefish (Foster 1965, 1966, and 1967). In 1990, whitefish also were collected from the Vernita Bridge to Priest Rapids segment of the Columbia River. Background samples were collected in 1991 from the Kettle River and again in 1995 from the Wenatchee River. Both rivers enter the Columbia River upstream of the Hanford Site.

Fish are very mobile, and the length of time they reside at any given sampling location is unknown. This mobility may explain why analytical results in fish generally are variable. Results for all 1995 samples are listed by Bisping (1996).

Radiological Results for Fish Samples

Muscle. In 1995, strontium-90 was detected in one (0.004 ± 0.003 pCi/g) of 18 whitefish muscle samples (Table 4.5.2). This observation may indicate the presence of some bone in the fillet, but is more likely a spurious result. Strontium-90 was not detected in the muscle of suckers.

Concentrations of cesium-137 in whitefish and sucker muscle were detectable in six of the 24 samples collected from all locations in 1995. Mean concentrations of cesium-137 in whitefish and sucker muscle were at or below the nominal detection limit of 0.02 pCi/g. The background fish collected from the Wenatchee River in 1995 appeared to have slightly higher levels then the background fish collected in 1990 from the Kettle River (Table 4.5.2). There is no demonstrable difference between cesium-137 concentrations in whitefish or suckers collected from the Hanford Reach and concentrations in fish collected from background locations during the past 5 years.

Neither uranium-238 nor technetium-99 was detected in three whitefish samples collected from the 300 Area in 1995. The nominal limits of detection for uranium-238 and technetium-99 are 0.001 pCi/g and 0.4 pCi/g, respectively.

Offal. Strontium-90 was found in all whitefish and sucker offal samples analyzed in 1995. The maximum concentration of 0.46 ± 0.09 pCi/g influenced the relatively high mean strontium-90 concentration for 1995. A comparison of the strontium-90 data from 1990 through 1994 indicates that strontium-90 concentrations in background samples from the Wenatchee and Kettle Rivers were higher than results from the Hanford Reach. Concentrations of strontium-90 in offal were slightly elevated in the 100-N to 100-D Area compared to the 300 Area.

In 1995, uranium isotopes were measured in offal samples from whitefish and suckers (Table 4.5.3). In prior years, edible fillets were analyzed for uranium; however, concentrations were below detection (0.02 pCi/g) and therefore offal was analyzed instead to account for the potential accumulation of uranium in bone tissue.

Wildlife Sampling

Wildlife sampled in 1995 for radioactive constituents included deer and geese. Pigeons were also collected as part of a graduate student project and were analyzed for trace metals. Results from all 1995 samples are summarized by Bisping (1996).

Collection and Analysis of Deer Samples

Samples were taken from two Hanford Site mule deer that were killed by traffic. A third deer (considered an onsite deer) that was tagged by Hanford biologists was provided by a local hunter that shot it in Franklin County. While deer hunting is not allowed onsite, deer do leave the Site, and a small number of deer potentially from Hanford are harvested annually from Columbia River islands and across the river in Grant and Franklin counties. Muscle and bone samples were analyzed for radioactivity. Roadkill samples are used whenever possible to minimize impacts to the Hanford deer population.

Table 4.5.2. Concentrations of Strontium-90 and Cesium-137 in Whitefish and Sucker (300 Area only), 1995 and the Previous 5 Years

Radionuclide	Sampling Location	Mean[a]	Maximum[b]	No. Less Than Detection[c]
	Muscle - 1995			
^{137}Cs	100-N - 100-D Areas	0.01 ± 0.01	0.02 ± 0.03	8 of 8
^{137}Cs	300 Area	0.01 ± 0.00	0.04 ± 0.04	3 of 4
^{137}Cs[d]	300 Area	0.01 ± 0.01	0.04 ± 0.03	4 of 6
^{137}Cs	Wenatchee River	0.00 ± 0.01	0.06 ± 0.03	4 of 7
^{90}Sr	100-N - 100-D Areas	0.001 ± 0.001	0.005 ± 0.014	8 of 8
^{90}Sr	300 Area	-0.013 ± 0.002	0.001 ± 0.003	4 of 4
^{90}Sr[d]	300 Area	0.001 ± 0.000	0.002 ± 0.003	6 of 6
^{90}Sr	Wenatchee River	0.000 ± 0.002	0.004 ± 0.003	5 of 6
	Muscle - 1990-1994			
^{137}Cs	100-N - 100-D Areas	0.02 ± 0.01	0.17 ± 0.04	31 of 50
^{137}Cs	300 Area	0.01 ± 0.00	0.04 ± 0.04	29 of 33
^{137}Cs	Priest Rapids-Vernita[e]	0.01 ± 0.01	0.04 ± 0.04	8 of 10
^{137}Cs	Kettle River	0.00 ± 0.01	0.04 ± 0.03	8 of 9
^{90}Sr	100-N - 100-D Areas	0.004 ± 0.002	0.012 ± 0.005	22 of 30
^{90}Sr	300 Area	0.000 ± 0.002	0.008 ± 0.015	18 of 18
	Offal - 1995			
^{90}Sr	100-N - 100-D Areas	0.094 ± 0.148	0.464 ± 0.088	0 of 8
^{90}Sr	300 Area	0.010 ± 0.006	0.018 ± 0.008	0 of 4
^{90}Sr[d]	300 Area	0.042 ± 0.007	0.053 ± 0.012	0 of 6
^{90}Sr	Wenatchee River	0.049 ± 0.010	0.071 ± 0.018	0 of 6
	Offal - 1990-1994			
^{90}Sr	100-N - 100-D Areas	0.021 ± 0.006	0.099 ± 0.029	1 of 47
^{90}Sr	300 Area	0.013 ± 0.002	0.035 ± 0.032	2 of 33
^{90}Sr	Priest Rapids-Vernita[e]	0.017 ± 0.005	0.032 ± 0.007	0 of 10
^{90}Sr	Kettle River	0.035 ± 0.006	0.048 ± 0.017	0 of 9

(a) Result is pCi/g ±2 standard error of the calculated mean.
(b) Maximum is pCi/g ±2 total propagated analytical uncertainty.
(c) Number of samples with values less than the detection limit out of number of samples analyzed.
(d) Sucker, 300 Area only; results for all other locations are whitefish.
(e) Discontinued in 1990.

Table 4.5.3. Concentrations of Uranium-238 in Whitefish and Sucker Collected in 1995

	Location	Mean[a]	Maximum[b]	No. Less Than Detection[c]
Muscle				
Whitefish	300 Area	0.000 ± 0.001	0.001 ± 0.001	3 of 3
Offal				
Sucker	300 Area	0.023 ± 0.015	0.056 ± 0.008	0 of 6
Whitefish	300 Area	0.001 ± 0.001	0.001 ± 0.001	0 of 4
Whitefish	100-N - 100-D Areas	0.009 ± 0.003	0.017 ± 0.004	0 of 8
Whitefish	Wenatchee River	0.012 ± 0.013	0.050 ± 0.009	0 of 7

(a) Mean is pCi/g ±2 standard error of the calculated mean.
(b) Maximum is pCi/g ±2 total propagated analytical uncertainty.
(c) Number of samples with values less than the detection limit out of number of samples analyzed.

Radionuclide concentrations in animals collected on the Site were compared to concentrations in deer collected distant from the Site from 1992 through 1994 at Boardman, Oregon and in Stevens County, Washington. The Stevens County deer samples were donated to the program. These comparisons are useful in evaluating Hanford's impact to deer; however, because the distant sampling area at Stevens County gets more rainfall than Hanford, background concentrations of cesium-137 and strontium-90 usually are higher in Stevens County deer than in onsite deer (Poston and Cooper 1994). This relationship was not noted in deer collected from Boardman because the climate and precipitation there are similar to Hanford.

Radiological Results for Deer Samples

Muscle. The concentration of cesium-137 in deer muscle collected near the 200 Area was 0.04 ± 0.01 pCi/g (Table 4.5.4). Cesium-137 was not detected in the two other deer samples collected at Hanford. A low frequency of cesium-137 results above the nominal detection levels (0.01 pCi/g) is consistent with trends observed in deer muscle in recent years (Poston and Cooper 1994). The cesium-137 concentration in Hanford deer muscle was less than background concentrations of cesium-137 measured in deer samples collected in 1992 and 1994 from Stevens County and collected in 1994 from Boardman.

Bone. Strontium-90 was detected in all deer bone samples analyzed in 1995. The maximum concentration was 0.18 ± 0.06 pCi/g in deer sampled from the old Hanford Townsite. Boardman deer bone samples had a maximum concentration of 0.13 ± 0.04 pCi/g strontium-90, which was lower than the Stevens County results but comparable to results for Hanford deer over the past several years (Table 4.5.4). The apparently higher concentrations of strontium-90 in onsite deer bone from 1990 through 1994 may indicate some prior exposure to low-level contamination onsite.

Liver. A single liver sample from a deer collected at the old Hanford Townsite was analyzed for plutonium-238 and plutonium-239,240. Concentrations of plutonium isotopes were below the nominal detection limit of 0.0004 pCi/g.

Collection and Analysis of Waterfowl Samples

Goose muscle was added to the routine surveillance schedule in 1994. In 1995, resident Canada geese were collected from the old Hanford Townsite and from the area between the 100-N and 100-D Areas. Goose eggshells were collected from 100-D Island (100-D Area) and from an island in the pool upstream of Priest Rapids Dam. Muscle tissues were analyzed for gamma emitters and strontium-90; eggshells and bone were analyzed for strontium-90.

Table 4.5.4. Concentrations of Strontium-90 in Deer Bone and Cesium-137 in Deer Muscle (pCi/g wet weight), 1995 Compared to Values from the Previous 5 Years

	1995			1990-1994		
Radionuclide/Location	Maximum[a]	Mean[b]	No. Less Than Detection[c]	Maximum[a]	Mean[b]	No. Less Than Detection[c]
^{90}Sr in Bone						
Onsite	0.18 ± 0.06	0.06 ± 0.12	1 of 3	58 ± 11	6.82 ± 7.8	0 of 15
Stevens County[d]				2.06 ± 0.41	1.08 ± 1.01	0 of 3
Boardman[e]				0.13 ± 0.04	0.11 ± 0.02	0 of 4
^{137}Cs in Muscle						
Onsite	0.04 ± 0.01	0.02 ± 0.02	2 of 3	0.37 ± 0.05	0.01 ± 0.02	20 of 35
Stevens County[d]				0.52 ± 0.06	0.31 ± 0.26	0 of 3
Boardman[e]				0.03 ± 0.03	0.01 ± 0.02	3 of 4

(a) Maximum is pCi/g ±2 total propagated analytical uncertainty.
(b) Result is pCi/g ±2 standard error of the mean.
(c) Number of samples with values less than the detection limit out of number of samples analyzed.
(d) Collected in 1992 and 1994, Whitetail deer; Mule deer are collected at Hanford. Stevens County is located in the northeast corner of Washington.
(e) Collected in 1994. Boardman is south of the Site in Oregon.

Radiological Results for Waterfowl Samples

Muscle. Cesium-137 was detected only intermittently in goose muscle (Table 4.5.5), concentrations were essentially at the limit of detection of 0.02 pCi/g. Strontium-90 was not detected in goose muscle. Sample collection in 1994 consisted of two geese, and there are no recent data to which 1995 results can be compared; however, the results are similar to background levels in ducks collected from Vantage, Washington in 1990 (Poston and Cooper 1994).

Strontium-90 concentrations in goose eggshells have declined in samples collected from the Hanford Reach (Figure 4.5.2). In 1995, there was essentially no difference between the background samples collected from the Priest Rapids pool (mean concentration of 0.40 ± 0.16 pCi/g) and the samples collected from 100-D Island (0.47 ± 0.13 pCi/g). For comparison, strontium-90 in chicken eggshells collected from the Sagemoor Area ranged from 0.13 ± 0.05 to 0.21 ± 0.05 pCi/g.

Collection and Analysis of Pigeon Samples

Pigeon samples were collected from background locations in Walla Walla and Seattle and were collected twice from the 300 Area, in January and September 1995. Each bird was sampled for kidney, liver, and muscle. Kidneys and livers were sampled because they accumulate trace metals. Muscle tissue was sampled because it may be consumed by humans and because concentrations of metals in pigeon muscle may be similar to concentrations in muscle tissues of upland gamebirds.

Nonradiological Results for Pigeon Samples

Only cadmium, chromium, copper, lead, and zinc were detected in pigeon samples (Table 4.5.6). Generally, metal concentrations were highest in birds collected in Seattle. Metal concentrations in tissues of pigeons collected in Walla Walla were similar to concentrations in

Table 4.5.5. Concentrations of Strontium-90 and Cesium-137 in Canada Goose Tissue, 1995

Location/Tissue	Radionuclide	Mean[a]	Maximum[b]	No. Less Than Detection[c]
100-N - 100-D Areas				
Bone	^{90}Sr	0.313 ± 0.284	0.717 ± 0.164	0 of 5
Muscle	^{90}Sr	0.000 ± 0.001	0.002 ± 0.002	5 of 5
Muscle	^{137}Cs	0.01 ± 0.00	0.01 ± 0.01	5 of 5
Hanford Townsite				
Bone	^{90}Sr	0.220 ± 0.141	0.439 ± 0.112	0 of 5
Muscle	^{90}Sr	0.000 ± 0.001	0.001 ± 0.003	5 of 5
Muscle	^{137}Cs	0.00 ± 0.01	0.01 ± 0.01	5 of 5

(a) Result is pCi/g ±2 standard error of the calculated mean.
(b) Maximum is pCi/g ±2 total propagated analytical uncertainty.
(c) Number of samples with values less than the detection limit out of number of samples analyzed.

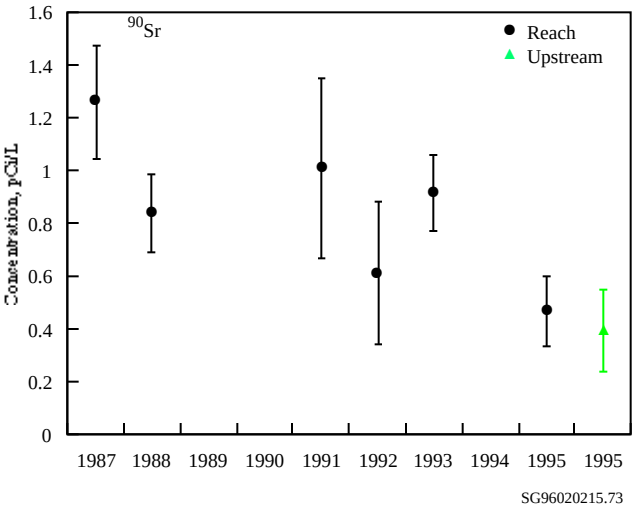

Figure 4.5.2. Mean Strontium-90 Concentrations in Goose Eggshells for Various Years Between 1987 and 1995

samples from the 300 Area. Pigeons collected in August from the 300 Area had higher concentrations of chromium in liver and muscle than birds collected in January. A similar relationship was observed for copper, lead, and zinc in liver tissue. Pigeons collected from Seattle would be expected to have greater concentrations of metals than pigeons collected at Hanford or Walla Walla because Seattle is more industrialized. These results suggest that concentrations of trace metals in 300 Area birds reflect a range of concentrations that likely are nonhazardous to pigeons.

Table 4.5.6. Trace Metal Concentrations in Pigeons, 1995

Tissue/Sampling Location	No. of Samples	Mean[(a)] (µg/g, dry weight) Cadmium	Chromium	Copper	Lead	Zinc
Kidney						
300 Area (January)	5	5.84 ± 4.6	0.53 ± 0.17	11.8 ± 2.4	0.38 ± 0.19	94.6 ± 5.66
300 Area (August)	5	1.81 ± 2.53	0.59 ± 0.04	17.8 ± 6.6	1.56 ± 1.33	104 ± 22.7
Seattle	8	10.9 ± 5.52	0.52 ± 0.08	20.6 ± 6.98	2.87 ± 2.15	101 ± 18.9
Walla Walla	7	5.27 ± 0.96	0.52 ± 0.06	15.7 ± 2.64	0.37 ± 0.38	115 ± 18.9
Liver						
300 Area (January)	5	0.68 ± 0.22	0.49 ± 0.07	8.45 ± 1.03	0.11 ± 0.02	59.5 ± 10.8
300 Area (August)	5	0.59 ± 0.74	0.81 ± 0.12	17 ± 4.62	0.69 ± 0.53	175 ± 94.9
Seattle	8	4.3 ± 2.4	0.81 ± 0.22	17.6 ± 4.95	1.75 ± 1.19	123 ± 60
Walla Walla	7	1.4 ± 0.38	0.72 ± 0.11	10.8 ± 1.33	0.17 ± 0.12	78.1 ± 19.4
Muscle						
300 Area (January)	5	0.08 ± 0.00	0.25 ± 0.04	18.8 ± 0.68	0.09 ± 0.01	37.4 ± 0.92
300 Area (August)	5	0.08 ± 0.00	0.4 ± 0.04	17.1 ± 0.5	0.13 ± 0.09	43.1 ± 4.62
Seattle	8	0.1 ± 0.02	0.39 ± 0.09	17.2 ± 1.23	0.11 ± 0.03	46.2 ± 4.67
Walla Walla	7	0.08 ± 0.00	0.42 ± 0.06	14.9 ± 0.81	0.08 ± 0.00	36.8 ± 3.94

(a) Result is ±2 standard error of the calculated mean.